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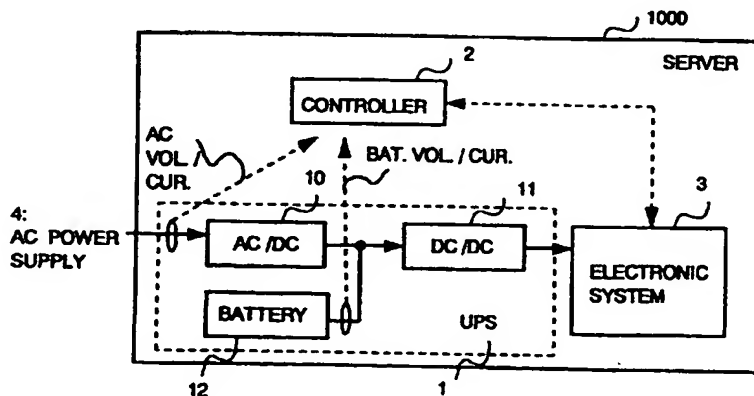
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(54) Uninterruptible power supplies

(57) An uninterruptible power supply for a system 3 such as a computer system comprises an a.c. power supply 4, an AC/DC converter 10, a battery 12 and a controller 2 for determining the power consumed by the system or the d.c. supplied by the battery and for calculating the life time of the battery based on the residual capacity of the battery and the measured power consumption or d.c. supplied by the battery. If the mains supply fails, power is supplied by the battery and a red warning light is switched on as well as an audible alarm. When the battery residual capacity is low, the red lamp flickers and the alarm sound increases. The power supply is closed down when the battery is fully discharged.

Fig.2



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Fig.1

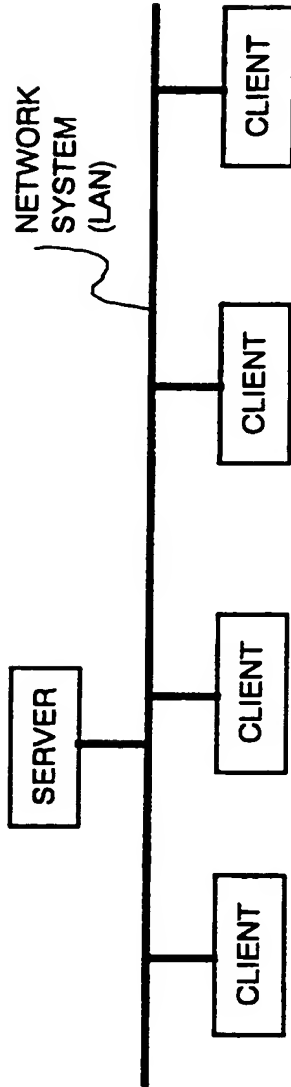


Fig.2

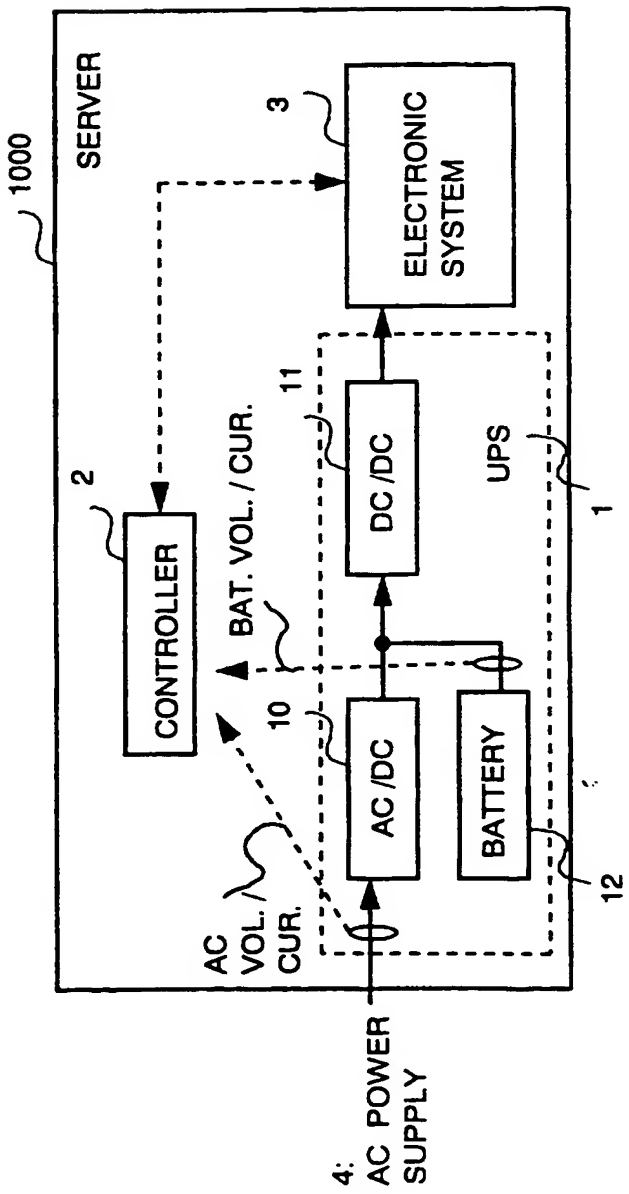


Fig.3

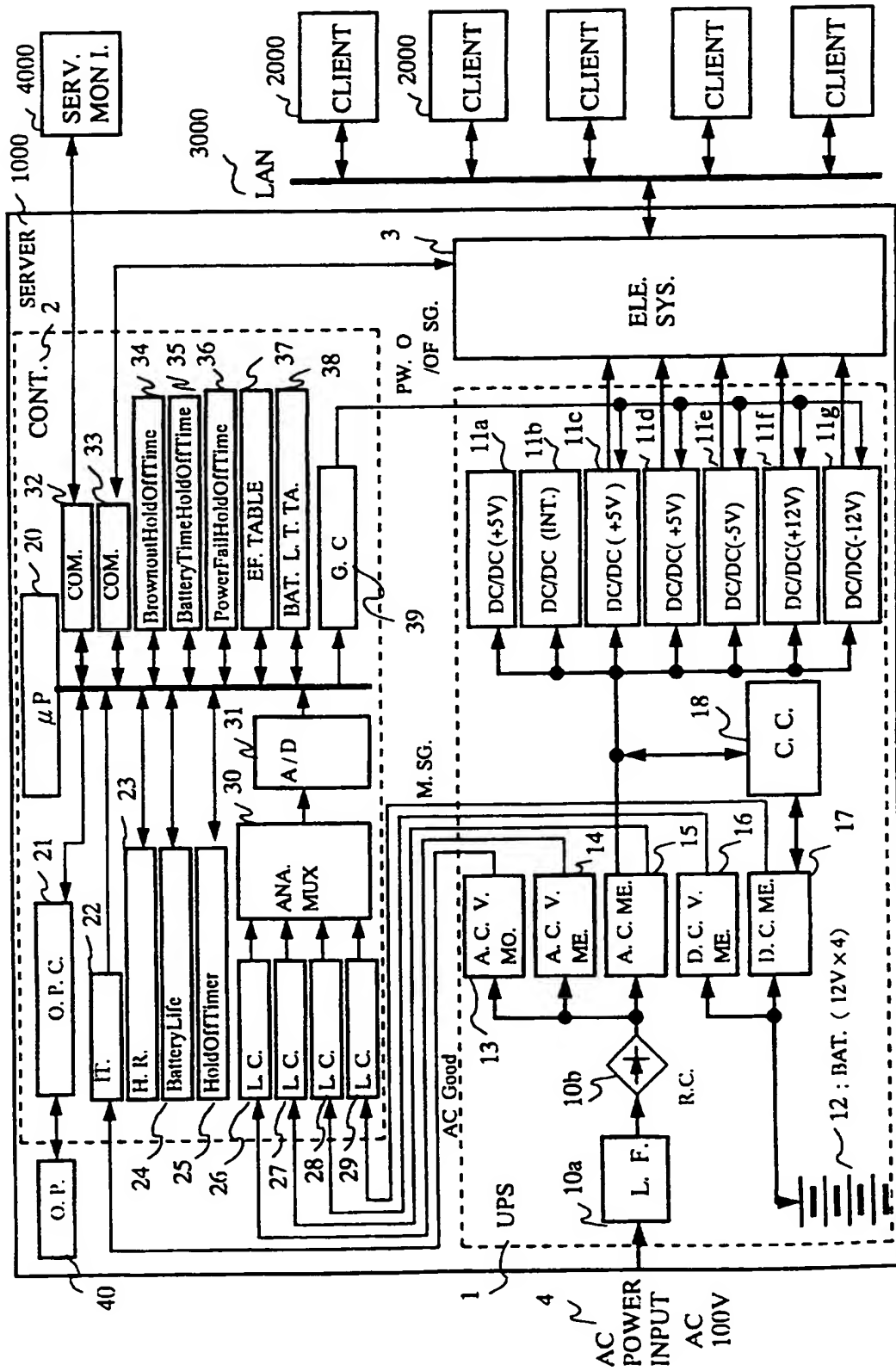


Fig. 4

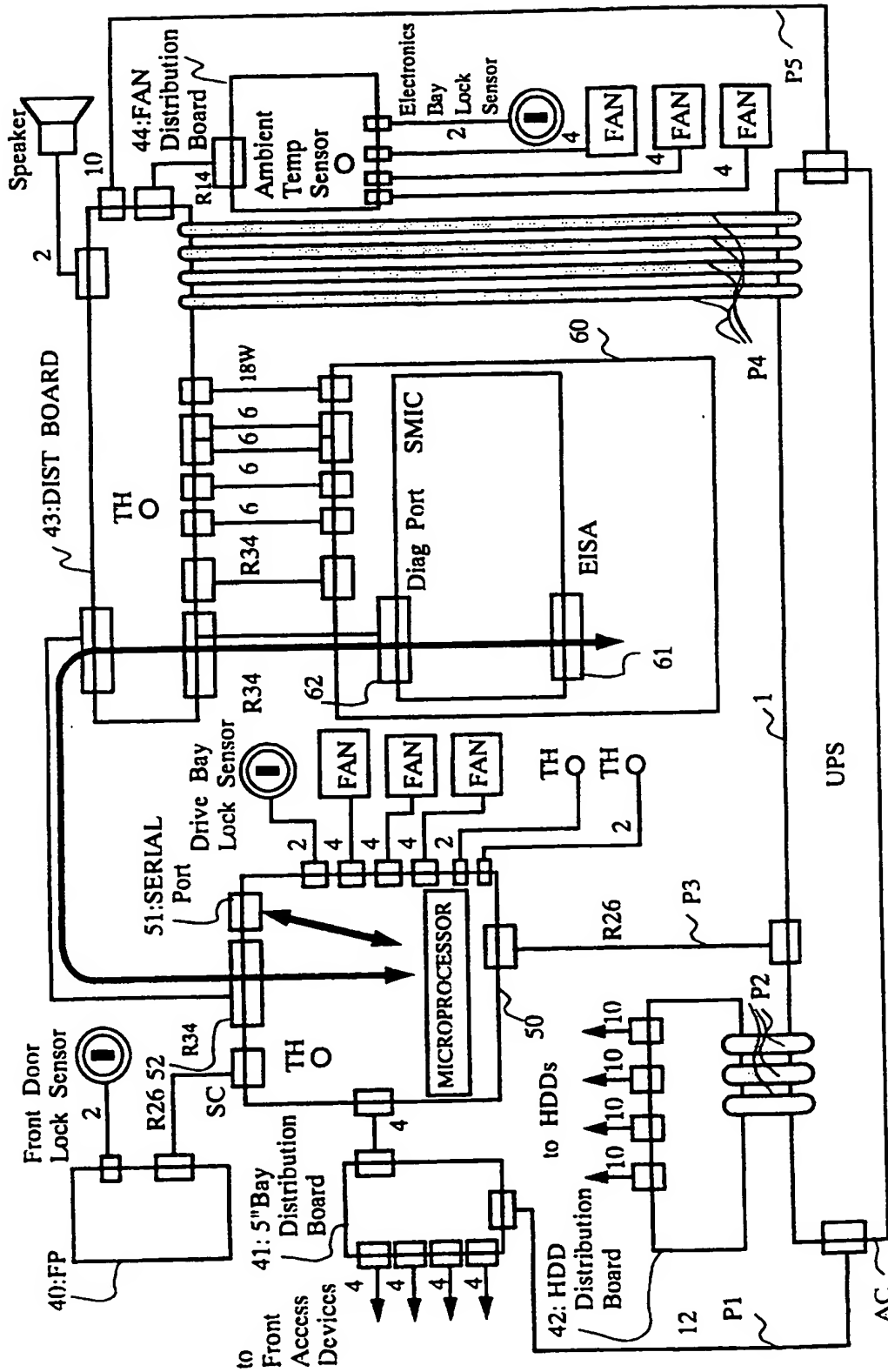


Fig.5

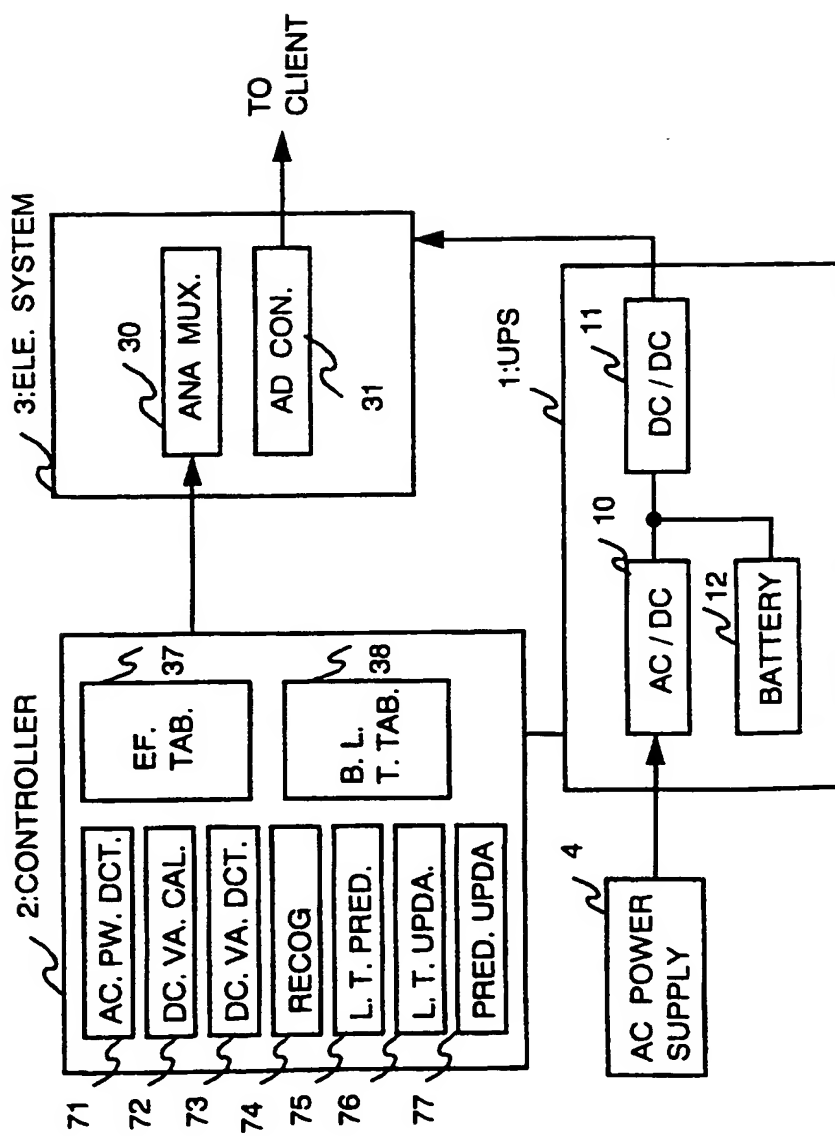


Fig.6

501	502	503a	503	504a	504	504b
SIGNAL	UPS I/O	TRUE	LEVEL	MEANING	FALSE	LEVEL
POWER UP	INPUT	0	0	STANDBY : GO TO POWER ON ACKNOWLEDGE : DC GOOD = TRUE)	1	NO ACTION
SHUTDOWN	INPUT	0	0	POWER ON : GO TO STANDBY (ACKNOWLEDGE : DC GOOD = FALSE) BACKUP, GO TO POWER OFF (ACKNOWLEDGE : DC GOOD = FALSE)	1	NO ACTION
AC GOOD	OUTPUT	1	1	AC INPUT IS SUITABLE AND THE PSU IS POWERED ENTIRELY BY AC	0	AC INPUT OUT OF SPEC. PSU MAY DRAW BATTERY CURRENT
DC GOOD	OUTPUT	1	1	DC OUTPUTS 0-2,3 AND 4 ARE WITHIN SPEC.	0	ONE OR MORE ARE NOT WITHIN SPEC
CIRCUIT BREAKER SENSE	OUTPUT	1	1	CIRCUIT BREAKER IS CLOSED, SO BATTERIES MAY SUPPLY DC POWER	0	CIRCUIT BREAKER IS OPEN, SO BATTERIES CANNOT SUPPLY DC POWER
THERMAL ALARM	OUTPUT	0	0	PSU COOLING FAILURE	1	TEMPERATURE OK

Fig.7

ANALOG CONTROL SIGNAL TABLE		
511 ✓	512 ✓	513 ✓
SIGNAL	UPS I/O	MEANING
DCO-2 MONITOR	OUTPUT	DELETED
AC VOLTS	OUTPUT	INDICATES RMS VALUE OF THE SINUSOIDAL VOLTAGE ON IEC 320 C20 INLET CONNECTOR
AC CURRENT MONITOR	OUTPUT	INDICATES RMS VALUE OF CURRENT DRAWN FROM THE AC SUPPLY
DC CURRENT MONITOR	OUTPUT	INDICATES THE AVERAGE CURRENT DRAWN FROM THE LEAD-ACID BATTERIES
BATTERY VOLTAGE MONITOR	OUTPUT	INDICATES LEAD-ACID BATTERY VOLTAGE

Fig.8

UPS MODE TRUTH TABLE		
520	521	522
STATE	AC GOOD	DC GOOD
DEAD	DON'T CARE	DON'T CARE
POWER OFF	FALSE	FALSE
STANDBY	TRUE	FALSE
POWER ON	TRUE	TRUE
BACKUP	FALSE	TRUE

Fig.9

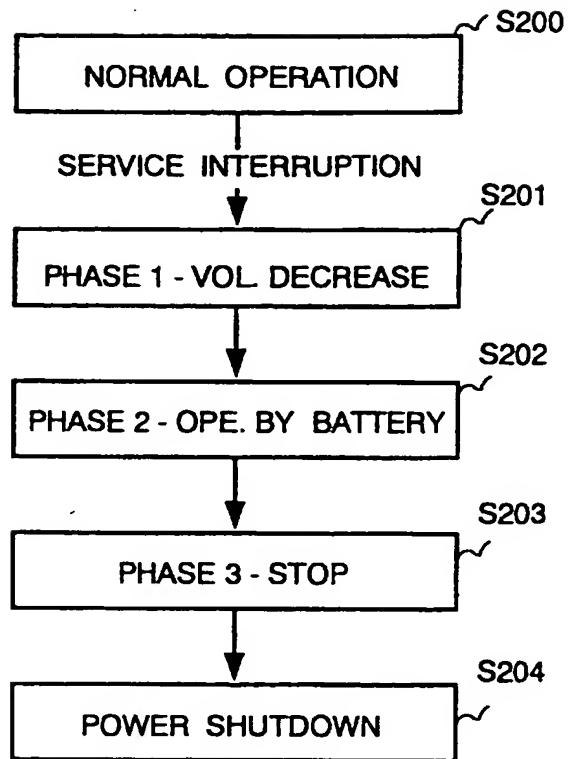
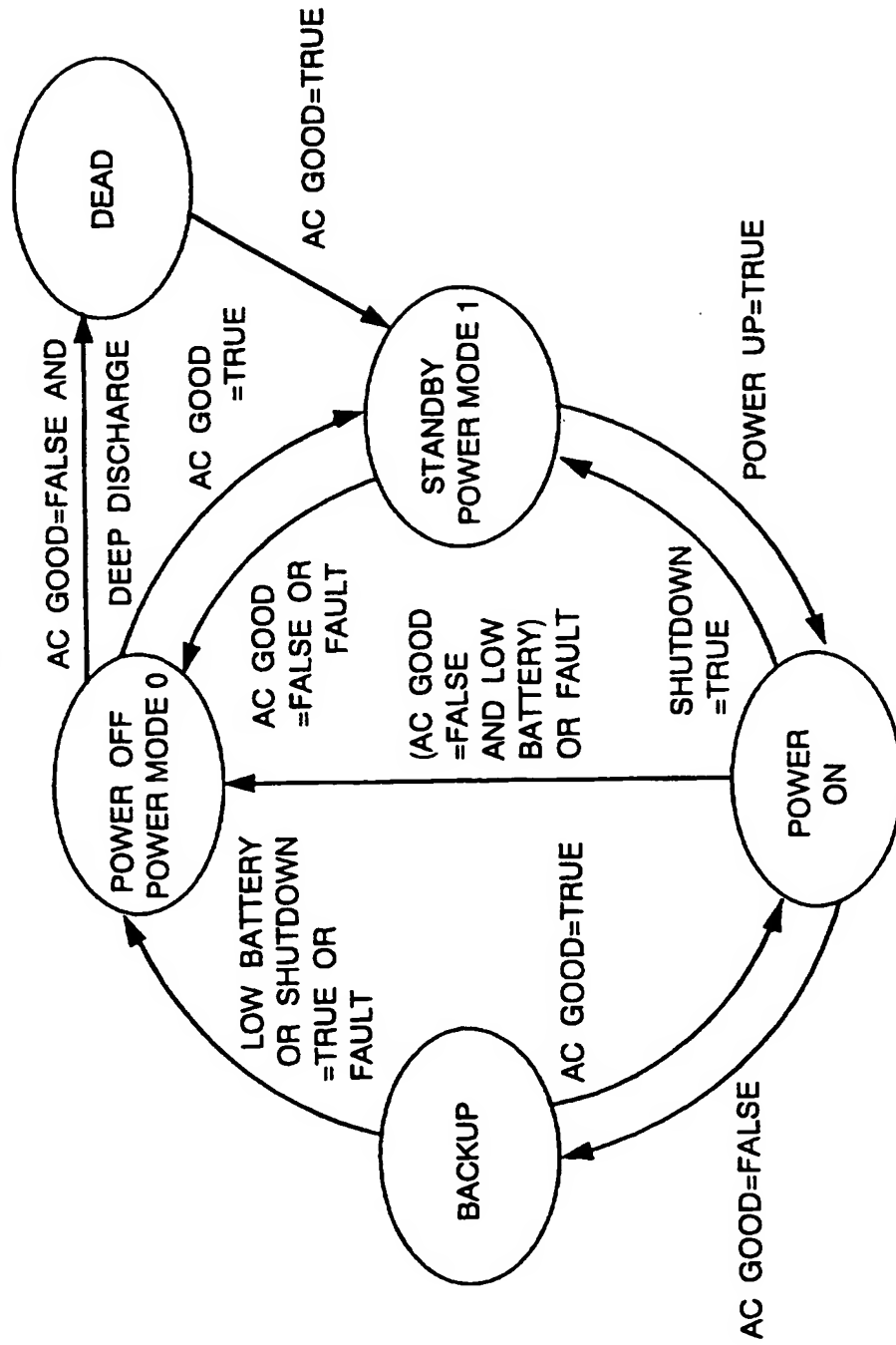


Fig.10

DISPLAY FOR UPS STATE

OPE. STATE	OPE. LUMP	WARNING	MEANING
NORMAL	GREEN	NOTHING	NORMAL OPE. (BAT. FULLY CHARGED)
	GR. FLICKER		NORMAL OPE. BAT. ON CHARGE
PHASE 1	RED	LOW SOUND	OPE. BY BATTERY
PHASE 2		HIGHER THAN PH.1	
PHASE 3	RED FLI.	HIGHER THAN PH.2	BAT. CAPACITY IS LITTLE
POWER SHUT DOWN	OFF	NOTHING	BAT. CAPACITY IS ZERO. OR POWER SWITCH OFF

Fig.11



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Fig.12

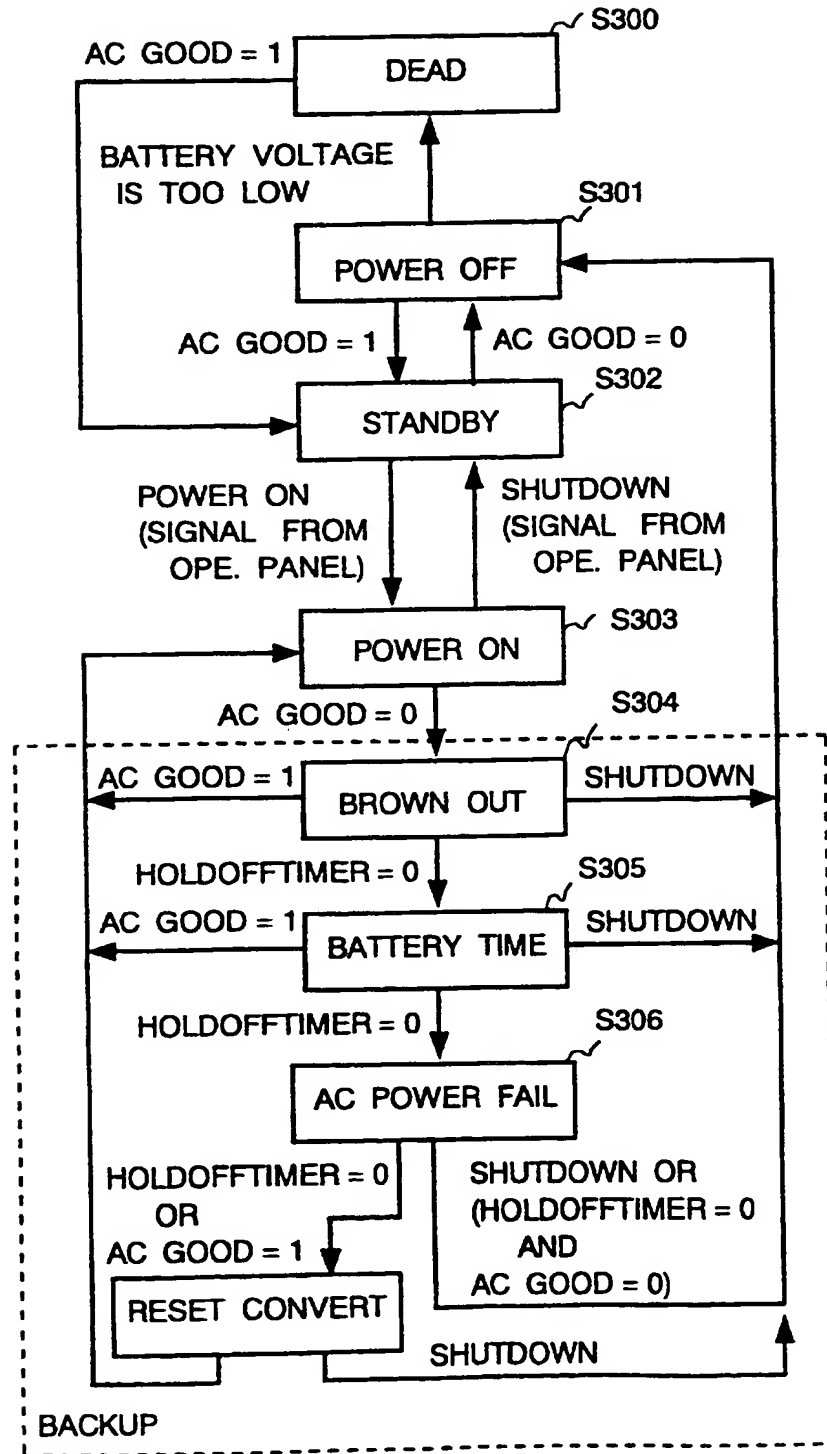


Fig.13

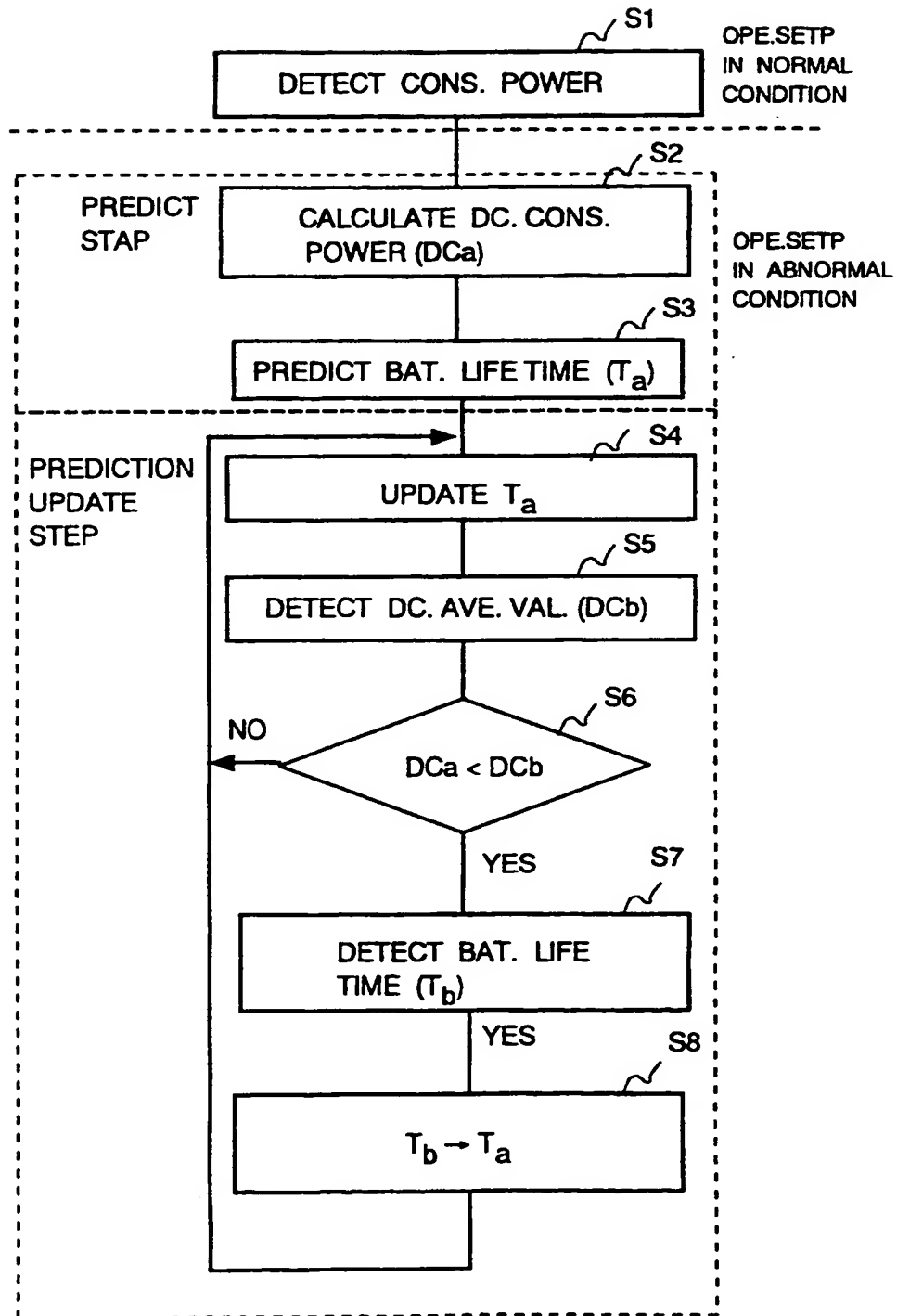


Fig.14

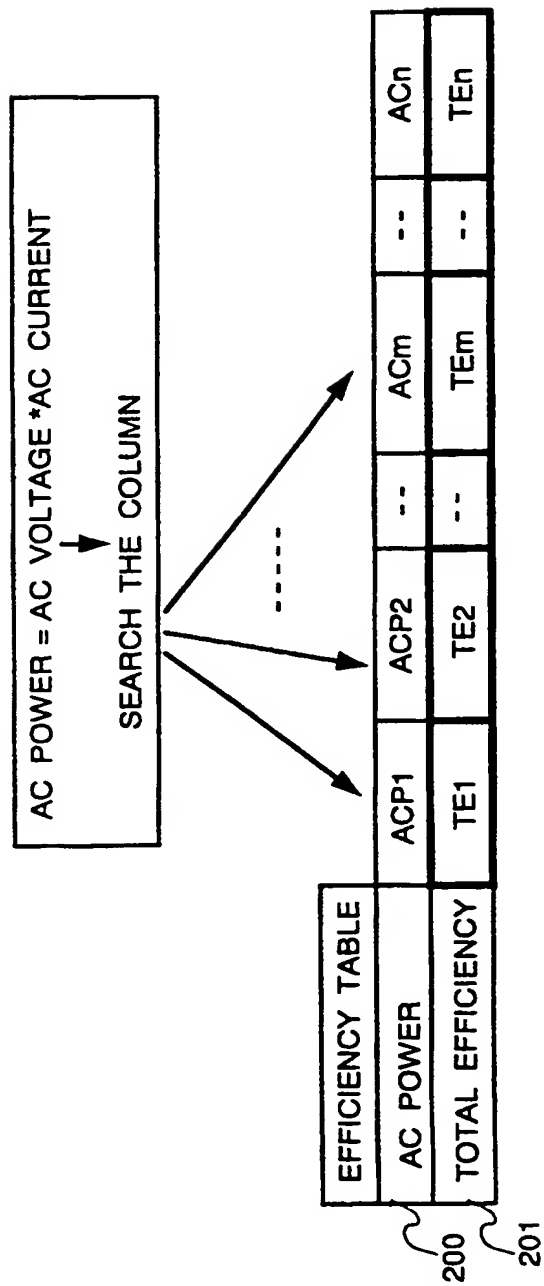


Fig.15

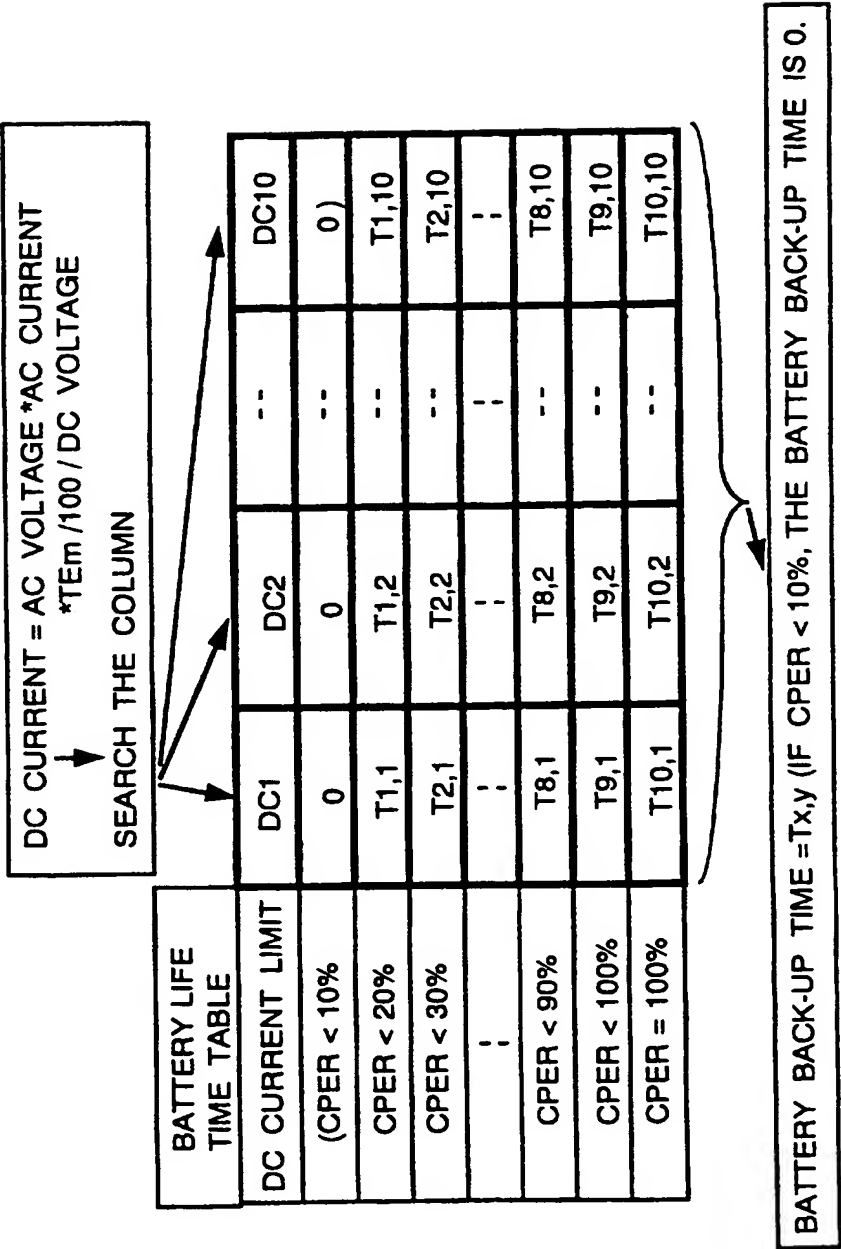


Fig.16

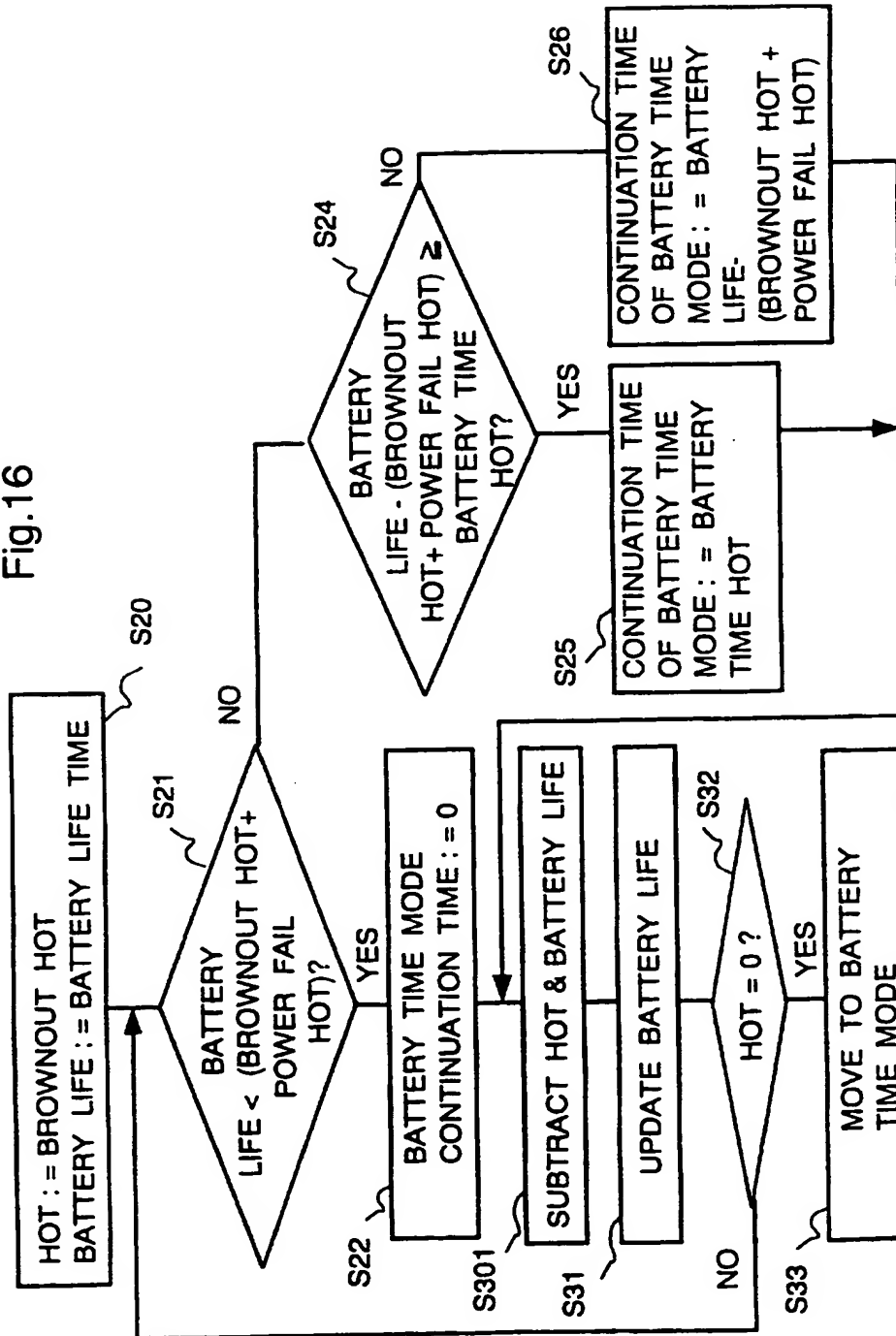


Fig.17

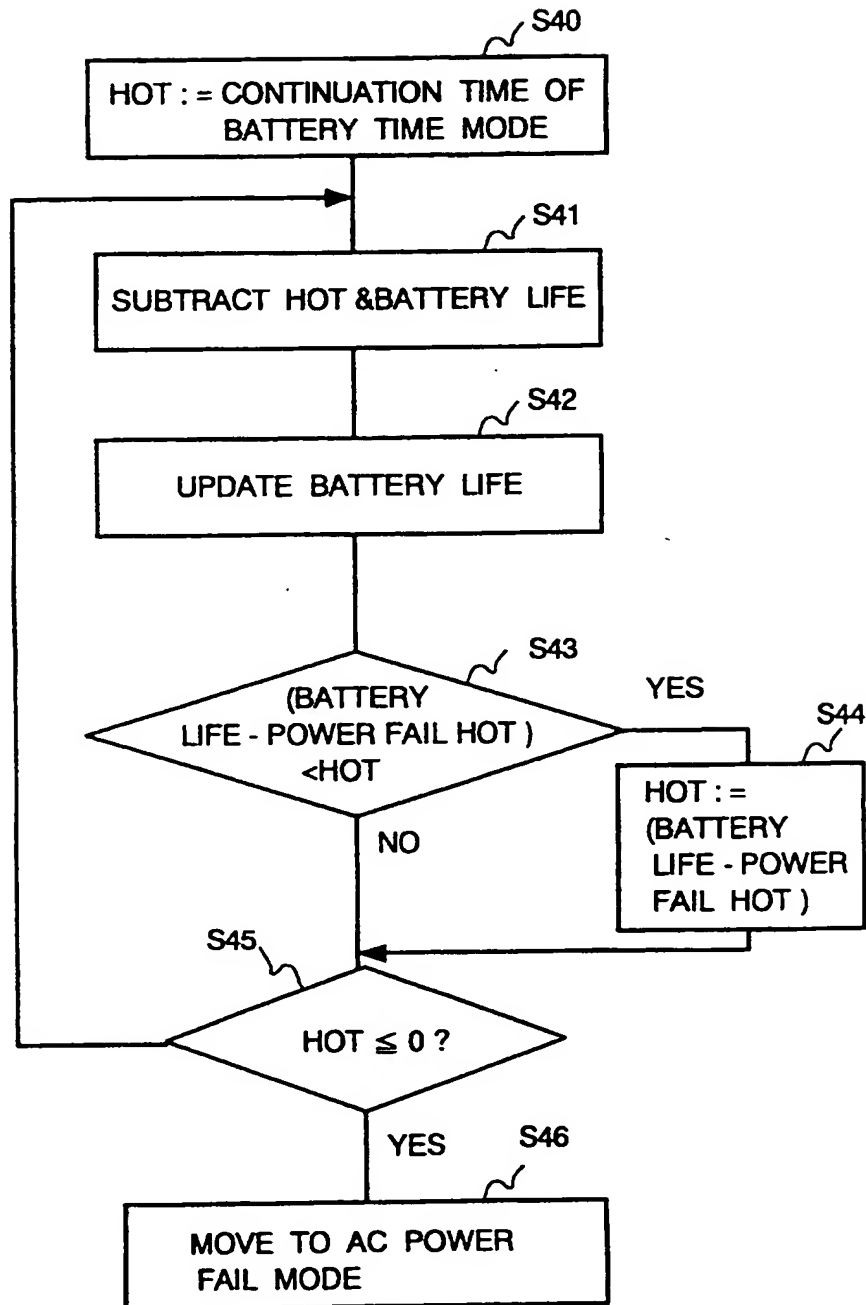
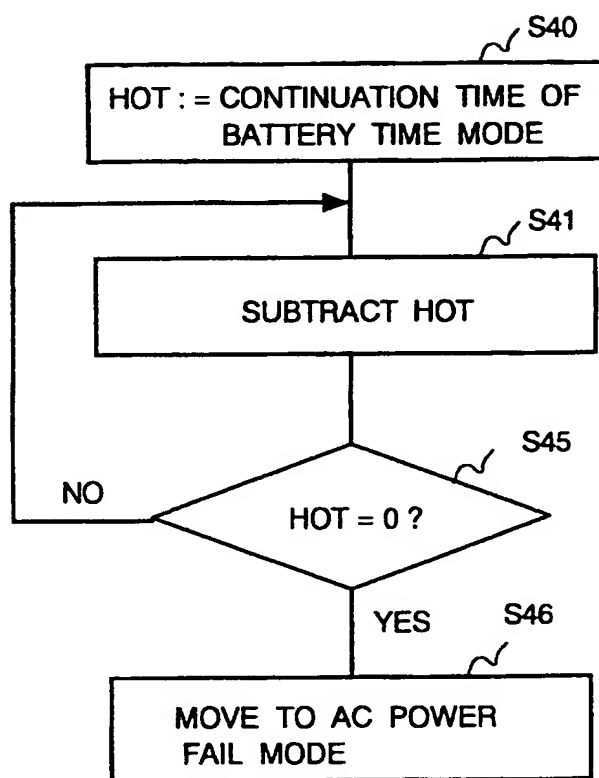


Fig.18



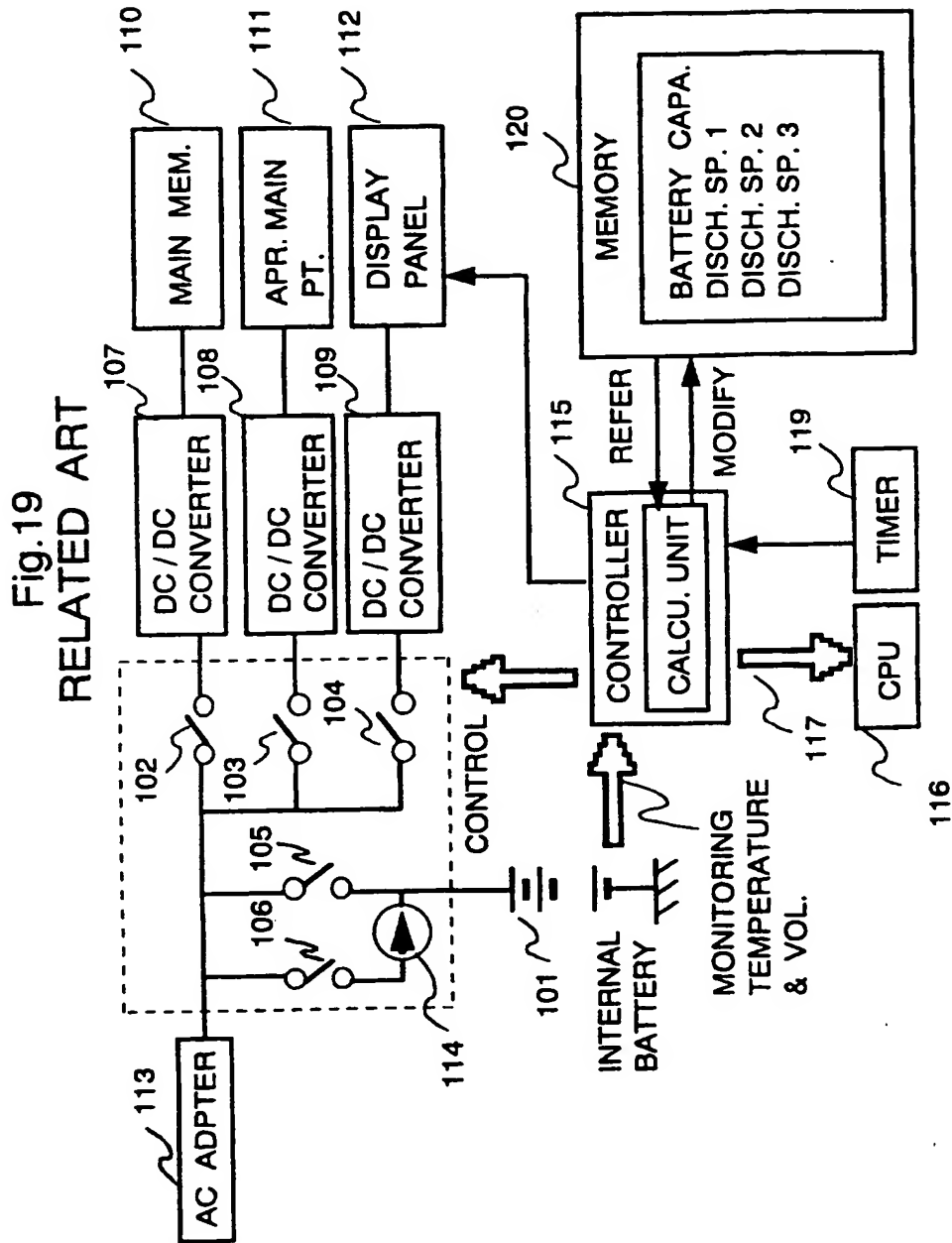


Fig.20
RELATED ART

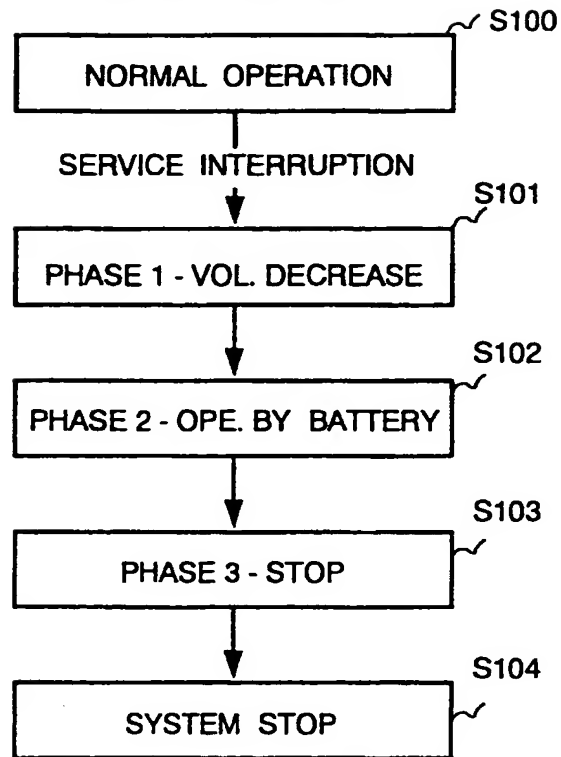


Fig.21
RELATED ART

OPERATION STATE	ALARM SOUND	OPERATION LUMP
NORMAL	NO SOUND	GREEN
PHASE 1	SLOW, HIGH	RED
PHASE 2	REPEAT HIGH&LOW	RED
PHASE 3	FROM HIGH TO LOW	RED FLICKER

2303979

A CONTROL SYSTEM AND CONTROL METHOD FOR
UNINTERRUPTIBLE POWER SUPPLY

This invention relates to a system and a method for controlling an uninterruptible power supply (UPS).

- 5 Particularly, it relates to a control system for stopping a system safely by accurately predicting a life time of a battery in the case of the system being operated by the battery of the UPS.

- 10 In the accompanying drawings, Fig. 19 is a block diagram showing "Residual Charging Capacity Detecting Apparatus for a Secondary Battery" disclosed in the Unexamined Japanese Patent Publication 7-20215.

- 15 In this related art, a battery 101 fully charged is discharged and its discharging time is measured at every operation state of an apparatus. It is defined that a value obtained by dividing battery charging capacity by the discharging time is a predicted discharging speed 1,

2, 3, The discharging speeds are stored in a memory
120 in advance. Operation states used for measuring the
discharging speed are normal operation state, suspend
state, backlight on state, backlight off state and so on.
5 The kinds of the operation state are limited and defined
permanently.

When an abnormal condition, such as power failure of
the alternating current, is generated and power from the
battery is provided to the apparatus, power consumption
10 can be calculated by using one of the predicted
discharging speeds 1, 2, 3,... stored in the memory 120
in advance based on the operation state of the apparatus,
without measuring an amount of direct current.

In "Information Processing Apparatus" disclosed in
15 the Unexamined Japanese Patent Publication 2-181210, a
technique for calculating a consumption amount of a
battery and residual charging capacity of the battery is
disclosed. The consumption amount of the battery is
calculated based on an average usage current amount and a
20 usage time needed for executing a designated process.
The residual charging capacity of the battery is
calculated based on charging capacity and consumption
amount.

"Battery State Monitoring Apparatus" disclosed in
25 the Unexamined Japanese Patent Publication 1-143984 has

the followings. A voltage measuring unit measures a voltage between terminals of the battery. A current measuring unit measures an amount of current used for charging and discharging of the battery. A temperature measuring unit measures a temperature of the battery. A calculation unit inputs values measured by the voltage measuring unit, current measuring unit and temperature measuring unit, and calculates residual charging capacity of the battery. A display device displays the residual charging capacity calculated at the calculation unit.

"Recognition Circuit for Battery Residual Charging Capacity" in the Unexamined Japanese Patent Publication 61-209372 discloses the following technique. Current for charging and discharging of the battery is detected and a peripheral temperature is detected by a temperature transducer. Charging rate and discharging rate are calculated using the detected current for charging and discharging and the detected peripheral temperature. Then, residual charging capacity of the battery is corrected using the above rates.

Apparatus and method for detecting residual charging capacity of the battery is also disclosed in the Unexamined Japanese Patent Publications 4-140678, 5-333119, 3-239125 and 5-333974.

Fig. 20 shows a state transition of the related UPS

at service interruption by power failure of the
alternating current. The UPS provides power from an
alternating current power supply (commercial power
supply) and includes an internal battery. When an
5 abnormal condition happens in providing the power from
the alternating current power supply, the UPS provides
power needed for operating the apparatus, from the
internal battery. The internal battery in the UPS is
charged by the alternating current power supply during
10 the apparatus operation. As power is provided from the
battery to the apparatus at the service interruption of
the alternating current power supply by using the UPS,
continuous operation can be performed safely in the
apparatus and safe stopping of the apparatus can be also
15 performed.

When service interruption is generated, a process
consisted of three phases is performed, as shown in Fig.
20. The UPS normally provides power from the alternating
current power supply at a step S100. If service
20 interruption is generated at this state, a process of
phase 1 is performed as shown in a step S101. The
process of phase 1 is performed during the first fifteen
seconds at the service interruption. The operation is
switched from using the alternating current power supply
25 to using the battery at the generation of the service

interruption. If the service interruption is returned to the normal condition during the fifteen seconds, the operation by the alternating current power supply is restarted.

5 If the service interruption is not returned to the normal condition during the fifteen seconds, the process goes to a phase 2 at a step S102. The operation by the battery is continued by the process of phase 2. A warning is given for the user at the phase 2 starting.
10 When the internal battery is charged fully, it is possible to supply the power for at most twenty-five minutes, for instance. However, the possible time of supplying the power depends upon the amounts and kinds of memories and peripheral devices included in the
15 apparatus.

 When the residual charging capacity of the battery becomes little, the process goes to a phase 3 as shown at a step S103. The phase 3 process gives warning to the outside that the residual charging capacity of the
20 battery becomes little, and performs stopping operation of the apparatus at once. Time of the phase 3 lasts for several minutes. However, processing time of the phase 3 changes depending upon a consumption state of the
25 battery. When the process of the phase 3 is finished, the system stops as shown in a step S104. In addition,

the UPS itself stops to prevent an over discharge from the battery.

5 The warning is given to the user based on the state of the UPS as shown in Fig. 21. The warning is consisted of an alarm and an operation lump. The user of the system can understand the state of the UPS because alarms and operation lumps corresponding to each phase are displayed. The user of the system performs preparing operation for the system stopping, such as saving files, finishing an application program, and performing log-out from the network, based on the outputted warning.

10 In Related Art, the power consumption is calculated using a measured discharging speed. In this case, it is only possible to calculate the power consumption at a fixed and simple operation state. It is not possible to calculate the power consumption corresponding to a complicated operation state. It is also impossible to deal with a configuration change of the electronic system and with a system wherein the power consumption is changed continuously according as the time passes.

20 In addition, it is only possible to infer residual charging capacity of the battery. Means for inferring a continuation time of the system, which the user of the electronic system really want to know, has not been provided. In fact, there is a case that the number of

CPU (central processing unit), memory amount and the number of disks, which are included in a server used for a server client system, can be flexibly changed.

Relating to operating software, a high level OS (operating system) is used and a large scale application software, such as data base software, is operated. There are many cases as stated above, it is necessary to accurately predict the continuation time of the system operated by the battery even when the hardware configuration of the system is changed or the power consumption is changed according as the time passes depending upon the operating software.

In Related Art, even in the case that the continuation time of the system is predicted, means for stopping the system safely using the predicted continuation time has not been provided. For example, as stated in the explanation about the state transition of the UPS at the service interruption with reference to Fig. 20, processing time for the phase 2 or 3 is changed depending upon the system configuration and residual charging capacity of the battery. Therefore, there has been a case that enough time needed for stopping the system safely is not ensured. In predicting the continuation time, the method of obtaining the continuation time by dividing battery residual charging

capacity by power consumption is confusing for the user.
The reason is that the power consumption increases and
decreases according as the time passes, then the
continuation time also increases and decreases, which
5 makes it impossible to stop the system safely. For
example, the continuation time predicted to be three
minutes first can be ten minutes suddenly and then rapidly
changed to be one minute. In this situation, it is
impossible for the system to determine whether just a
10 warning should be made or an actual stopping process
should be started. In fact, there is a case that when the
system starts preparation for stopping based on service
interruption information toward OS and an application
program, most of disk devices and memories are used
15 enormously, which brings about a large increase of the
power consumption. It is necessary to stop the system
safely even in such a case.

In order to solve the above-mentioned problems,
it is an object of the present invention to provide an
20 uninterruptible power supply (UPS) which can predict a
life time of a battery accurately based on an inferred
power consumption corresponding to any system

configuration.

It is another object to provide the UPS which can precisely predict a possible operation time of the system operated by the battery even when operation state is not fixed and power consumption changes continuously and momentarily.

It is another object to provide the UPS which can stop the system safely based on predicted possible operation time.

According to one aspect of the present invention, a control system for uninterruptible power supply comprises (a) an uninterruptible power supply including a battery for supplying direct current (DC), for inputting alternating current (AC) from an alternating current power supply, converting the alternating current into direct current and outputting the direct current from one of the alternating current power supply and the battery (b) an electronic system operated by inputting the direct current output from the uninterruptible power supply, and (c) a controller for calculating a value of power consumption of the electronic system while the electronic system is operated by the direct current produced from the alternating current power supply,

for calculating a life time of the battery based on

residual charging capacity of the battery and the value of power consumption, when the electronic system starts operation by power from the battery, and

for outputting the life time to the electronic system.

According to another aspect of the present invention, a control system for uninterruptible power supply comprises

(a) an uninterruptible power supply including a battery for supplying direct current, for inputting alternating current from an alternating current power supply,

converting the alternating current into direct current and outputting the direct current from one of the alternating current power supply and the battery

(b) an electronic system operated by inputting the direct current output from the uninterruptible power supply, and

(c) a controller for calculating a life time of the battery based on residual charging capacity of the battery and a value of direct current from the battery, while the electronic system is operated by power from the battery, and for outputting the life time to the electronic system.

According to another aspect of the present invention, a control method for uninterruptible power

supply, used for an electronic system operated by
uninterruptible power supply, comprises the steps of
(a) operating the electronic system by an alternating
current power supply at an ordinary time

5 (b) measuring power consumption during the electronic
system operated by the alternating current power supply,
in the operating step at an ordinary time

(c) operating the electronic system by a battery at an
extraordinary time

10 (d) predicting a life time of the battery based on
residual charging capacity of the battery and the power
consumption measured by the power consumption measuring
step, at a starting time of the operating step at an
extraordinary time, and

15 (e) controlling operation of the electronic system based
on the life time of the battery predicted by the
predicting step.

According to another aspect of the present
invention, a control method for uninterruptible power
supply, used for an electronic system operated by

20 (a) operating the electronic system by an alternating
current power supply at an ordinary time

(b) operating the electronic system by a battery at an
25 extraordinary time

- (c) periodically detecting residual charging capacity of the battery and an average value of direct current from the battery at a specific period while the electronic system is operated by the battery, in the operating step
5 at an extraordinary time, and predicting and updating a life time of the battery based on the average value of the residual charging capacity of the battery and the direct current from the battery, and
(d) controlling operation of the electronic system based
10 on the life time of the battery predicted by the predicting and updating step.

The invention will be further described by way of non-limitative example, with reference to the accompanying drawings, in which:-

15 Fig. 1 shows an example of UPS of the present invention;

Fig. 2 shows a block diagram of UPS system of the present invention;

20 Fig. 3 shows another block diagram of UPS system of the present invention;

Fig. 4 shows a configuration of hardware for UPS

control system of the present invention;

Fig. 5 is a block diagram logically showing UPS control system of the present invention;

5 Fig. 6 shows a table for digital control signal according to an embodiment of the present invention;

Fig. 7 shows a table for analog control signal according to the embodiment of the present invention;

Fig. 8 shows a table for UPS mode truth table according to the embodiment of the present invention;

10 Fig. 9 shows a state transition of UPS at a service interruption, according to the present invention;

Fig. 10 shows a display for UPS state transition at a service interruption, according to the present invention;

15 Fig. 11 shows a chart for UPS state transition according to the present invention;

Fig. 12 shows another chart for UPS state transition according to the present invention;

20 Fig. 13 shows a flowchart of life time prediction process according to the present invention;

Fig. 14 shows an efficiency table according to the present invention;

Fig. 15 shows a table for battery life time, according to the present invention;

25 Fig. 16 shows a flowchart of process in Brown Out

mode, according to the present invention;

Fig. 17 shows a flowchart of process in Battery Time mode, according to the present invention;

Fig. 18 shows another flowchart of process in
5 Battery Time mode, according to the present invention;

Fig. 19 shows a block diagram of a residual charging capacity detecting apparatus for a secondary battery in Related Art;

Fig. 20 shows a state transition of UPS at a
10 service interruption in Related Art; and

Fig. 21 shows a display for state transition of UPS at a service interruption in Related Art.

Fig. 1 shows a configuration of a system of an embodiment of the present invention. A network system (or
15 local area network) 3000 of this embodiment is a server client system including a server 1000 and a plurality of clients 2000.

Fig. 2 shows a configuration of the server 1000. An uninterruptible power supply (UPS) 1, a controller 2
20 and an electronic system 3 are provided in the server 1000. The electronic system 3 may be a computer system, a

measuring system, a working system, and any other system.

A converter for alternating current to direct current (AC/DC converter) 10, a converter for direct current to direct current (DC/DC converter) 11 and a battery 12 are included in the UPS 1. The controller 2 inputs values obtained by measuring an alternating current voltage and an alternating current amount of an alternating current power supply 4. The controller 2 also inputs values obtained by detecting a direct current voltage and a direct current amount of the battery 12. The controller 2 predicts a life time of the battery 12 based on the inputted alternating current voltage, alternating current amount, direct current voltage and direct current amount.

Fig. 3 shows a detailed configuration of the hardware of the server 1000 shown in Fig. 2. The AC/DC converter 10 of the UPS 1 includes a line filter 10a and a rectifying circuit 10b, and converts the alternating current to the direct current. A monitor 13 for alternating current voltage monitors a voltage of alternating current in order to recognize starting of power supply from the alternating current power supply 4 and find generation of an abnormal condition in the alternating current power supply 4. The monitor 13 for alternating current voltage outputs an AC Good signal to the controller 2. The AC Good signal shows whether the

alternating current power supply 4 is normally supplying the power or not.

5 A measuring unit 14 for alternating current voltage measures alternating current voltage from the alternating current power supply 4. A measuring unit 15 for alternating current measures an amount of alternating current from the alternating current power supply 4. A measuring unit 16 for direct current voltage measures a voltage of direct current of the battery 12. A measuring unit 17 for direct current measures a direct current amount of the battery 12. Values measured by the measuring units 14 to 17 are output to the controller 2 as monitor signals.

15 A controlling circuit 18 for charging and discharging charges the battery 12 by power from the alternating current power supply 4. When an abnormal condition is generated in the alternating current power supply 4, the controlling circuit 18 for charging and discharging supplies power from the battery 12 to the electronic system 3. DC/DC converters 11a to 11g generate direct current of various voltages needed for operating the UPS 1, the controller 2 and the electronic system 3, and outputs the generated direct current.

20 A microprocessor 20 included in the controller 2 performs various controls when the system is operated by

the alternating current power supply 4 and the battery 12. Firmware (F/W, not shown) is also included in the controller 2, to work with the microprocessor 20. An operation panel controller 21 displays conditions of the alternating current power supply 4 and the battery 12, using an operation panel 40. An interrupt circuit 22 inputs the AC Good signal from the monitor 13 for alternating current voltage in order to check starting of power supply and generation of an abnormal condition in the alternating current power supply 4, and informs the microprocessor 20 of the conditions of the alternating current power supply 4. The controlling circuit 18 controls supplying power from the battery 12. A holding register 23 for average consumed power is a register for holding an average amount of direct current consumed during a specific period while the system is operated by the battery 12. A battery life register 24 is a register for storing a battery life time predicted by the controller 2. A hold off timer 25 is a register for counting down life times of various modes when the system is operated by the battery 12. Level converters 26 to 29 input values measured by the measuring units 14 to 17 in the UPS 1, as monitor signals and convert levels of the inputted signals. An analog multiplexer 30 inputs values from the level converters 26 to 29, multiplexes the

inputted values and outputs the selected values. An
analog digital converter 31 converts analog values of
voltage and current to digital values. A communication
unit 32 communicates with a personal computer (called a
5 sever monitor, hereinafter) 4000 for management. The
server monitor 4000 has a maintenance function of
monitoring and managing the server 1000 from a remote
place. A communication unit 33 communicates with the
electronic system 3. The communication unit 33 gives
10 warnings and directions to the electronic system 3 during
the battery 12 operation. A brownout holdoff time
register 34, a battery time holdoff time register 35 and
a power fail holdoff time register 36 are registers for
setting each time of three modes (stated later) in the
15 case of the system being operated by the battery 12. An
efficiency table 37 is a table for storing efficiency of
converting alternating current to direct current. A
battery life time table 38 is a table for calculating a
life time of the battery based on residual charging
20 capacity of the battery and an amount of direct current
discharged from the battery. A generation circuit 39 for
power on/off signal recognizes a state whether a power
switch of the system (not shown) is on or off, and
generates a power on/off signal. When the power switch
25 is off, the DC/DC converters 11c to 11g do not operate

and a power supply to the electronic system 3 is stopped.

Fig. 4 shows a configuration of physical configuration in the server 1000 shown in Figs. 2 and 3. The UPS 1 is put in one box and supplies power to boards in the server 1000. A control board 50 including the controller 2 and a system board 60 including the electronic system 3 are in the server 1000. The operation panel (or front panel) 40, 5 inches bay distribution board 41, hard disk drive (HDD) distribution board 42, distribution board 43 and fan distribution board 44 are also in the server 1000. The UPS 1 is connected to boards via lines P1 to P5. Each of the lines P1 to P5 is consisted of plural lines. The UPS 1 supplies power to each board and each device directly or indirectly, using a part of the plural lines. The lines P2 and P4 are exclusive lines for power supply, and high capacity lines than lines P1, P3 and P5 are used for them. Therefore, it is possible to supply enough power from the lines P2 and P4 to boards and devices which consume a large amount of power.

Plural fans are applied inside the server 1000. Rotation of the fans is controlled based on a detected temperature of a thermal sensor TH. Various kinds of lock sensors are also applied in the server 1000.

A serial port 51 is used for the communication unit

32 in order to communicate with the server monitor 4000 for management. A port 52 is used for the communication unit 33 and connected to a port 62 via the distribution board 43 so as to make the control board 50 communicate with the system board 60.

Numbers beside signal lines in Fig. 4 indicate the numbers of the signal lines. Number 4, beside the signal line connecting the 5 inches bay distribution board 41 and the control board 50, indicates that there are four signals lines between the boards 41 and 50, for instance. A letter R and number beside the signal line indicates the numbers of the signal lines and that a ribbon cable is used. For example, R26 besides the signal line connecting the UPS 1 and the control board 50 indicates that a ribbon cable having twenty-six signal lines is used for the line P3. The above stated signal lines for supplying power and signal lines for transmitting AC Good signals, monitor signals and power on/off signals shown in Fig.3 are included in the twenty-six signal lines of the line P3 connecting the control board 50 and UPS 1.

Fig. 5 illustrates a logical configuration of the controller and an electronic system of the server. Various means in the controller 2 shown in Fig. 5 are accomplished using the hardware, such as the microprocessor 20, the registers 23 to 25, and 34 to 36,

firmware and software (not shown) in the controller 2 of Fig. 3. The microprocessor 20, the firmware and the software operate as follows using the registers and the tables in the controller 2 shown in Fig. 3.

5 An AC power detecting means 71 calculates alternating current power based on a value of the alternating current voltage and an amount of the alternating current measured by the measuring unit 14 for alternating current voltage and the measuring unit 15 for
10 alternating current. A DC value calculating means 72 calculates DC values corresponding to alternating current power, using the calculated alternating current power by the AC power detecting means and the efficiency table 37. A DC value detecting means 73 detects an average value of
15 direct current of the battery measured by the measuring unit 17 for direct current. Values detected by the DC value detecting means 73 are stored in the holding register 23 for average consumed power. A recognition means 74 for residual charging capacity recognizes
20 residual charging capacity of the battery based on the measured voltage by the measuring unit 16 for direct current voltage, by using a known method as stated in the Related Art. The characteristic of the present invention is to detect a life time of the battery based on the
25 residual charging capacity of the battery, not to detect

residual charging capacity of the battery. Therefore,
method for detecting the residual charging capacity of
the battery is not stated in this embodiment.

5 A life time predicting means 75 predicts an initial
life time of the battery using the DC value calculated by
the DC value calculating means 72 and the battery life
time table 38. A life time updating means 76 counts down
a predicted life time according as time passes. A
prediction updating means 77 repeatedly updates the life
10 time of the battery using the average amount of consumed
direct current detected by the DC value detecting means
73 and the battery life time table 38. The prediction
updating means 77 also compares the life time counted
down by the life time updating means 76 with a new
15 predicted life time, and sets a shorter life time of the
two as a new life time.

A receiving means 90 of the electronic system 3
receives a state of processing at the controller 2 and a
warning from the controller 2. An outputting means 91
20 outputs warnings to the clients 2000 or to the outside
based on the state and the warning received by the
receiving means.

Figs. 6 and 7 show tables of signals input and
output at the UPS 1. The above stated AC Good signals,
25 monitor signals and the power on/off signals are included

in these tables. Fig. 6 shows a table for digital control signals and Fig. 7 for analog control signals.

A column for signal 501 in the table of Fig. 6 shows kinds of the digital control signal. A column for UPS I/O 502 shows whether the digital control signals are input or output at the UPS. Columns for Level 503a in True 503 and Level 504a in False 504 show values of the digital control signal and Meaning 503b and Meaning 504b show meaning of each Level.

The table for analog control signal in Fig. 7 has columns of Signal 511, UPS I/O 512 and Meaning 513. The column of Signal 511 shows kinds of the analog control signal. The column of UPS I/O 512 shows whether the analog control signals are input or output. The column of Meaning 513 shows meanings of the analog control signals.

Fig. 8 is a table showing UPS mode truth value. This UPS mode truth value table shows a state of UPS in State 520 column, truth value of the AC Good signal in AC Good 521 column, and truth value of the DC Good signal in DC Good 522 column.

Three phases of the UPS of this embodiment will now be described with reference to Fig. 9.

When service interruption is generated in the UPS 1 during a normal operation at a step S200, the state is

switched to a phase 1, at a step S201. Similar to the Related Art, time needed for the phase 1 is a fixed time. The time for the phase 1 in this embodiment is defined to be fifteen seconds, for instance. If the alternating
5 current power supply returns to a normal condition during the phase 1, the system returns to the normal operation. If the time defined in advance (fifteen seconds in this embodiment) has passed without the alternating current power supply being returned to the normal condition, the
10 state goes to a phase 2 shown in a step S202. It is a great advantage of this embodiment that time needed for the phase 2 is variable. Setting method of the variable time for the phase 2 will be described later. If the alternating current power supply is returned to the
15 normal condition during the phase 2, the state, similar to the phase 1, goes back to the normal operation shown in the step S200. If the defined time has passed without the alternating current power supply being returned to the normal condition, the state goes to a phase 3 at a
20 step S203. Differing from the Related Art, time needed for the phase 3 is secured. For example, time needed for a electronic system to stop the operating system (OS) is set as the fixed time. After finishing the process of stopping the OS, the phase 3 is finished. In a special
25 case, that is, at the real residual charging capacity of

the battery becomes zero, the phase 3 is finished before the fixed time is passed. Then, the state goes to a step S204 of shutting down the power of the system.

The user can be informed of the state transition such as the above by display of an operation lamp applied at the operation panel 40. Simultaneously, a warning (alarm sound) is given to the user. Outputs of the operation lamp and the alarm corresponding to each phase of Fig. 9 are shown in Fig. 10. When the operation lamp is green, it indicates that the system is operated by the alternating current power supply. When red, it indicates operated by the battery of the UPS. If the green of the operation lamp is flickering, it indicates that the system is operated in the normal condition and the battery of the UPS is on charge. The red of the operation lamp is on during the periods of the phase 1 and the phase 2. Relating to the alarm, it sounds low during the phase 1 and sounds higher than the phase 1 during the phase 2. The user can be informed that the system is operated with the battery of the UPS, by the alarm sound.

When the state is moved to the phase 3, the red of the operation lamp starts flickering, so that the user is informed that the residual charging capacity of the battery of the UPS becomes very little. The alarm sounds

higher than the phase 2 at this stage. When the phase 3 is finished and the power of the system is shut down, the alarm and the operation lump are turned out.

5 If there is residual charging capacity in the battery of the UPS even after the power of the system being shut down, the communication unit 32 can respond to a connection to the serial port 51 from the server monitor 4000. In the case of the communication unit 32 being on the response to the server monitor 4000, the operation lump becomes red once, and the lump turns to
10 off again when the response is finished.

The state transition at the service interruption seen from the user has been described with reference to Fig. 9. State transition of the UPS corresponding to the control signals is shown in Fig. 11. The UPS of this
15 embodiment changes in five states depending upon values of the control signals as shown in Fig. 11. The signal used in Fig. 11 is either the digital control signal or the analog control signal. The state "Back up" in Fig. 11 includes the phases 1 to 3 shown in Fig. 9 altogether.
20 A chart of state transition of the UPS showing detailed explanation of the state "Back up" is displayed in Fig. 12. Steps from a step S301 of Power Off mode to a step S306 of AC Power Fail mode will now be explained. A
25 variable Power mode is used to indicate each mode.

Power Off mode

During Power Off mode, the value of Power mode is set at 0 (Power Off). For example, in this Power Off mode, the power switch is not on and a power plug is not connected to an outlet of the alternating current power supply 4. In this mode, the H/W of the controller 2 is in a sleep mode and the controller 2 does not execute system state monitoring. When the power plug is connected to the outlet and the controller 2 detects the AC Good signal becoming active by the interrupt circuit 22, the H/W of the controller 2 leaves the sleep mode, and the microprocessor 20 and F/W set the Power mode at 1 (Standby).

Standby mode

During Standby mode, the value of Power mode is set at 1 (Standby). In this mode, the controller 2 does not execute system state monitoring. When the microprocessor 20 and F/W detect the AC Good signal becoming inactive, the microprocessor 20 and F/W set the Power mode at 0 (Power Off) and begin to sleep. At this time, if the microprocessor 20 and F/W of the controller 2 communicate with some remote connected clients, the timing of sleeping will be delayed until the communication ends. When the microprocessor 20 and F/W detect the DC Good signal becoming active (by manual, remote or automatic

power switch on). the microprocessor 20 and F/W set the Power mode at 2 (Power On).

Power On mode

During Power On mode, the value of Power mode is set at 2 (Power On). In this mode, the controller 2 executes system state monitoring. When the controller 2 activates a shutdown signal (shown in Fig. 6) to UPS, or the controller 2 detects the DC Good signal becoming inactive during the AC Good is active, the microprocessor 20 and F/W set the Power mode at 1 (Standby). When the controller 2 detects the DC Good signal becoming inactive or the battery voltage becoming too low, and then the AC Good is inactive, the microprocessor 20 and F/W set the Power mode at 0 (Power Off) and begin to sleep. When the controller 2 detects the AC Good becoming inactive during the DC Good is active, the microprocessor 20 and F/W set the Power mode at 3 (Brownout) and set the hold off timer 25 at Brownout Hold Off Time in the register 34 and start to count down the hold off timer 25. The microprocessor 20 and F/W will also generate a trap to the communication unit 33 in order to inform the electronic system that the Power mode has been changed.

Brownout mode

Brownout mode corresponds to phase 1. During Brownout mode, the value of Power mode is set at 3

(Brownout). The microprocessor 20 and F/W of the controller 2 decrease the hold off timer 25 by one every second. When the controller 2 activates the shutdown signal to UPS (by shutdown request or emergency power-off condition) or the controller 2 detects the DC Good signal becoming inactive or the battery voltage becoming too low, the microprocessor 20 and F/W stop the hold off timer 25 and set Power mode at 0 (Power Off) and then begin to sleep. When the controller 2 detects AC Good becoming active, the microprocessor 20 and F/W stop the hold off timer 25 and set the Power mode at 2 (Power On). The microprocessor 20 and F/W will also generate a trap to the communication unit 33 in order to inform the electronic system 3 that the Power mode has been changed. When the hold off timer 25 expires, the microprocessor 20 and F/W set the Power mode at 4 (Battery Time) and set the hold off timer 25 at Battery Time Hold Off Time in the register 35, and start the hold off timer. The microprocessor 20 and F/W will also generate a trap to the communication unit 33 in order to inform the electronic system 3 that the Power mode has been changed.

Battery Time mode

Battery Time mode corresponds to phase 2. During Battery Time mode, the value of Power mode is set at 4 (Battery Time). The microprocessor 20 and F/W of the

controller 2 decrease the hold off timer 25 by one every
second. When the controller 2 activates the shutdown
signal to UPS (by shutdown request or emergency power-off
condition), or the controller 2 detects the DC Good
5 signal becoming inactive or the battery voltage becoming
too low, the microprocessor 20 and F/W set the Power mode
at 0 (Power Off) and stop the hold off timer 25 and then
begin to sleep. When the controller 2 detects AC Good
becoming active, the microprocessor 20 and F/W set the
10 Power mode at 2 (Power On) and stop the hold off timer
25. The microprocessor 20 and F/W will also generate a
trap to the communication unit 33 in order to inform the
electronic system 3 that the Power mode has been changed.
When the hold off timer 25 expires, the microprocessor 20
15 and F/W set the hold off timer 25 at Power Fail Hold Off
Time in the register 36, and start the hold off timer 25
and set the Power mode at 5 (AC Power Fail). The
microprocessor 20 and F/W will also generate a trap to
the communication unit 33 in order to inform the
20 electronic system 3 that the Power mode has been changed.
AC Power Fail mode

AC Power Fail mode corresponds to phase 3. During
AC Power Fail mode, the value of Power mode is set at 5
(AC Power Fail). The microprocessor 20 and F/W of the
25 controller 2 decrease the hold off timer 25 by one every

second. When the controller 2 activates the shutdown
signal to UPS (by shutdown request or emergency power-off
condition), or the controller 2 detects the DC Good
signal becoming inactive or the battery voltage becoming
5 too low, the microprocessor 20 and F/W stop the hold off
timer 25 and set the Power mode at 0 (Power Off) and then
begin to sleep. Even if the controller 2 detects AC Good
signal becoming active during AC Power Fail mode, the
microprocessor 20 and F/W persist the AC Power Fail mode.
10 When the hold off timer 25 expires, if the AC Good signal
is active, the microprocessor 20 and F/W set the Power
mode at 7 (Reset Convert). When the hold off timer 25
expires, if the AC Good signal is inactive, the
microprocessor 20 and F/W activate the shutdown signal
15 immediately and set the Power mode at 0 (Power Off) and
then begin to sleep.

Fig. 13 shows a flowchart of life time predicting
process performed by the controller 2. The AC power
detecting means 71 detects consumed power based on the
20 alternating current power supply, at a step S1.
Alternating current voltage and alternating current
amount are measured at every specific period in order to
obtain a value of consumed power. Then, a value of
direct current power consumption of the system can be
25 calculated at a step S2. An average value of the direct

current power consumption is calculated at a specific period, such as ten seconds. Calculating the value of the direct current power consumption is necessary for predicting a life time of the battery. The efficiency table 37 shown in Fig. 14 is used for calculating the direct current power consumption of the system based on the measured alternating current voltage and alternating current amount. As the efficiency and a power factor of the power supply are not fixed, the efficiency table 37 is used for the calculation. There is an advantage that it is possible to flexibly deal with various types of UPS having a different characteristic, by rewriting the content of the efficiency table 37 from the outside. It is also acceptable to provide an efficiency table corresponding to a different voltage, such as 100V or 240V.

As shown in Fig. 14, alternating current power is calculated by multiplying the alternating current voltage by the alternating current amount in order to obtain the direct current power consumption. Referring to a column of AC power 200 in the efficiency table 37 based on the calculated value of the alternating current power, a value of the efficiency can be obtained, at the corresponding alternating current power value. Then, the battery life time table 38 is consulted based on the

obtained efficiency value.

Fig. 15 shows the battery life time table 38. Residual charging capacity of the battery are placed in the columns vertically aligned and amounts of the direct current are placed in the columns laterally aligned, in the battery life time table 38. The amount of direct current can be calculated by the following equation.

$$\text{DC amount} = \frac{\text{AC voltage} \times \text{AC amount} \times \text{Efficiency}}{100 \times \text{DC voltage}}$$

A battery life time T_a is obtained by referring to the battery life time table 38, using the value of the direct current obtained by the above equation and the battery charging capacity recognized by the recognition means 74 for residual charging capacity, as shown at a step S3 in Fig. 13. The above process of predicting the life time based on the alternating current power is performed only once by the life time predicting means 75 when the alternating current power supply 4 is switched to the battery.

The battery life time T_a is updated according as actual time passes, as shown in a step S4 of Fig. 13. When the battery life time T_a is expressed in seconds, 1 is subtracted from the value of the T_a according as every actual second passes. The subtraction of the battery life time T_a is performed by the life time updating means

76.

Even after the battery life time is predicted using the direct current power consumption calculated based on the measured alternating current, the operation state of the system and the consumed power change every moment. Especially when the system starts preparation for operation stopping, the value of the power consumption changes greatly. The life time of the battery is estimated continuously in the UPS of this embodiment for the purpose of corresponding with such a great change of the power consumption.

The DC value detecting means 73 measures an amount of current discharged from the battery at every specific period to calculate an average value at each specific period, as shown in a step S5 of Fig. 13. When a calculated average value DCb is larger than a direct current value DCa predicted based on the alternating current voltage and the alternating current amount, the life time of the battery is predicted again based on the battery life time table 38 using the calculated average value DCb, as shown in a step S6 of Fig. 13. At a step S7, a battery life time Tb is referred in the battery life time table 38, based on the calculated average value DCb of the direct current, and the battery residual charging capacity recognized by the recognition means 74

for residual charging capacity. A value of battery life time Ta is over written by the value of the battery life time Tb, as shown in a step S8 of Fig. 13. The prediction updating means 77 updates the battery life time by repeating the steps from S5 to S8.

Overestimation of the life time of the battery, caused by increase or decrease of the power consumption of the system, is prevented by calculating the average value of the direct current discharged from the battery continuously. In addition, length of the period interval and length of the period for measuring an average value of direct current is defined to be shorter than the length of the period interval and the length of period for measuring during the operation by the alternating current power supply. The reason is that it is necessary for the life time estimation to reflect a quick and dynamic change of the power consumption during the operation by the battery.

The following operation mode switching is needed for safely performing the continuous operation of the system and safely stopping operation of the system, using the battery life time calculated as the above.

After switching from the alternating current power to the battery power, caused by a stop of the alternating current power supply or a decrease of the voltage, the

mentioned three modes are performed in the controller.

(1) Brownout mode :

As mentioned, this mode corresponds to the phase 1. The stop of alternating current power supply or the decrease of voltage in this mode is assumed to be temporary, so that operation of the system is continued. If necessary, the software sends a warning to a system user. In the case that the alternating current power supply is returned to the normal condition during this mode, the system operation can be continued without getting any influence. If the alternating current power supply does not return to the normal condition within a defined time, it goes to Battery Time mode.

(2) Battery Time mode :

As mentioned, this mode corresponds to the phase 2. The stop of alternating current power supply or the decrease of voltage in this mode is assumed to be continuous. If the battery continues to be consumed, the mode is changed to AC Power Fail mode, and the system starts stopping process. When a software (not shown) in the electronic system is informed of entering this mode, the software, if necessary, tells that the system is going to start stopping operation in a defined time to a system user of this electronic system or to the clients and to another computer system connected to this

electronic system via lines and local area network (LAN).

(3) AC Power Fail mode :

As mentioned, this mode corresponds to the phase 3. When the software in the electronic system is informed of entering this mode, the software immediately starts stopping operation of the system. After the stopping process being finished, the controller is informed of finishing the stopping process and then stops power outputting from the UPS.

There is a possibility of the battery becoming dead during the system operation, because the battery life time becomes short depending upon the residual charging capacity of the battery or the power consumption state of the system. Accordingly, length of continuation time of each mode is dynamically determined based on the following procedures, in this embodiment.

The following three values are set in registers 34, 35 and 36 of the controller in advance, as the maximum value of the continuation time length of each mode.

(1) Brownout Hold Off Time :

This time is necessary to cover a time for instant service interruption or instant voltage decrease, generation of which can be anticipated in the environment of alternating current power supply used in the electronic system. Therefore, the Brownout Hold Off Time

is a relatively short time (for example, fifteen seconds) which is a relatively longer than the time for instant service interruption or instant voltage decrease.

(2) Battery Time Hold Off Time :

5 This is a time for the system user to prepare for the system stopping, after the stop of electronic system previously being announced. If there is enough charging capacity of the battery for the power consumption of the system, this Battery Time Hold Off Time is defined to be
10 long.

(3) Power Fail Hold Off Time :

 This time is necessary for the electronic system to stop.

 Values of the above times can be changed from the
15 outside in order to deal with a system changing flexibly. Therefore, even if the power consumption of the system is changed largely by a change of the system configuration and so on, it is possible to set new appropriate values for the system.

20 Switching of the three operation modes will now be explained with reference to Figs. 16 to 18.

 Fig. 16 shows a flowchart of determining process of a continuation time of Battery Time mode in Brownout mode. The controller calculates the life time of the
25 battery based on the battery residual charging capacity,

system power consumption and battery life time table,
using the above method while the electronic system is
operated by the alternating current power supply. The
calculated life time is stored in the battery life
5 register 24. In the case that the battery is not fully
charged during the electronic system being operated by
the alternating current power supply, residual charging
capacity is inferred based on charging time in every
specific period. A value of the battery life time is
10 continued to be updated.

When the controller detects that the alternating
current power supply is switched to the battery because
the alternating current power supply is stopped or the
voltage decreases, the mode moves to Brownout mode. A
15 value of Brownout Hold Off Time is used for a
continuation time of Brownout mode. The controller sets
the value of Brownout Hold Off Time in the hold off timer
25, as shown in a step S20 of Fig. 16.

At a step S21, a value of battery life register 24
20 (battery life time) is compared with a value of (Brownout
Hold Off Time + Power Fail Hold Off Time). If the
Battery Life value is smaller than the value of (Brownout
Hold Off Time + Power Fail Hold Off Time), the
continuation time of Battery Time mode is made to be
25 0(zero) at a step S22. However, even in this case, the

mode does not move to Battery Time mode until the value of hold off timer 25 becomes 0(zero). The reason is that it is necessary to prevent the system from entering into frequent starting process and frequent stopping process caused by each instant service interruption or each instant voltage decrease. When "No" is given at the step S21, a value of battery life register 24 - (Brownout Hold Off Time + Power Fail Hold Off Time) is compared with Battery Time Hold Off Time which is set in the register 35 in advance, at a step S24. When the value of Battery Life - (Brownout Hold Off Time + Power Fail Hold Off Time) is larger than Battery Time Hold Off Time, that is "YES " given at a step S25, the smaller time, that is Battery Time Hold Off Time, is defined to be the continuation time of Battery Time mode. If the value of battery life - (Brownout Hold Off Time + Power Fail Hold Off Time) is smaller than Battery Time Hold Off Time, that is "NO" given at a step S26, the smaller time of the two, that is Battery Life - (Brownout Hold Off Time + Power Fail Hold Off Time), is assigned to be the continuation time of Battery Time mode.

At a step S30, values of the hold off timer 25 and battery life register 24 are subtracted at every specific period until they become zero, at a step S30. The values of them are subtracted every one second, for instance.

The Battery Life is updated by the prediction updating means 77, at a step S31. When a value of the hold off timer 25 becomes 0(zero) at a step S32, the mode moves to the Battery Time mode as a step S33.

5 Though it is not shown in Fig. 16, if the alternating current power supply is returned to the normal condition during the Brownout mode as shown in Figs. 11 and 12, the controller informs the software of the normal state, and the system returns to the normal
10 operation.

 Accordingly, when the battery is fully charged, Battery Time Hold Off Time set in advance is used as a continuation time of Battery Time mode. In the case that the battery is not fully charged, a time corresponding to
15 a residual charge amount in the battery is used as the continuation time of Battery Time mode. If there is never enough residual charging capacity in the battery, the Battery Time mode is passed and it is moved to the AC Power Fail mode immediately to start the system stopping.

20 Fig. 17 shows a flowchart of process in Battery Time mode. The continuation time for Battery Time mode, which is defined by the above process, is set in the hold off timer 25, at a step S40. The value of this set time is subtracted at every specific period until it becomes
25 zero. Similarly, the value of the Battery Life is

subtracted, at a step S41. Simultaneously, as stated
above, the value of the Battery Life is always updated
based on an actual measured value of discharged power
from the battery, at a step S42. At a step S43, a value
5 of (Battery Life - Power Fail Hold Off Time) is compared
with a value of the hold off timer 25 to check whether
the value of (Battery Life - Power Fail Hold Off Time) is
smaller than the value of the hold off timer 25. If YES
is given, the value of (Battery Life - Power Fail Hold
10 Off Time) is set in the hold off timer 25, at a step S44.
When the value of the hold off timer 25 becomes 0(zero),
the mode moves to the AC Power Fail mode at steps S45 and
S46.

15 If the alternating current power supply is returned
to the normal condition during the Battery Time mode, the
controller informs the software of the normal state, and
the system returns to the normal operation.

20 As stated above, the battery life time set at
battery life resistor 24 is updated continuously, so that
it is possible to deal with a dynamic change of power
consumption. The time needed for the system to perform a
safe stopping, can be maintained by switching operation
mode with predicting an accurate life time. In the
Battery Time mode, it is also acceptable not to
25 repeatedly update Battery Life time set at battery life

register 24 by the prediction updating means 77, by using the continuation time determined in the Brownout mode. A flowchart in this case is shown in Fig. 18. The continuation time of the Battery Time mode is set in the hold off timer 25 just after it moves to the Battery Time mode, as shown in Fig. 18. When the value set in the hold off timer 25 becomes 0(zero), the mode moves to the AC Power Fail mode.

A value of Power Fail Hold Off Time is used as a continuation time of the AC Power Fail mode. The controller sets the value of the Power Fail Hold Off Time in the hold off timer 25. The value in the hold off timer 25 is subtracted at every specific period until it becomes 0(zero). Simultaneously, a value of the Battery Life is subtracted and the value of the Battery Life is repeatedly updated based on an actual measured value of discharged power from the battery, as stated above. If the value of the hold off timer 25 becomes zero, or power shutdown is required by the software in the electronic system since the preparation for the system stopping is finished, the controller stops power outputting of the UPS.

In the case of Battery Life < (Brownout Hold Off Time + Power Fail Hold Off Time) at the switching time from the alternating current power supply to the battery,

there is a possibility of the battery life time becoming
0 (zero) before the hold off timer 25 becomes zero at the
AC Power Fail mode because the battery life time is a
calculated value. Although there is above stated
possibility, sometimes there is a case that the battery
has some residual charged amount in fact. Therefore, the
operation is continued until the hold off timer 25
becomes 0(zero) at the Brownout mode. However, if it is
detected that the battery is discharged perfectly and an
output voltage of the battery becomes lower than a
specific value, the power output from the UPS is stopped
at once.

When the alternating current power supply is
returned to the normal condition during periods of the
Brownout Mode and Battery Time mode, the controller
informs the software of the normal state, and the system
returns to the normal operation. Even if the alternating
current power supply is returned to the normal condition
during the AC Power Fail mode, process of AC Power Fail
mode is continued because the system is already in the
stopping process.

As stated above, there is an effect that the battery
life time of just after being switched to the battery,
can be more accurately predicted by measuring the
alternating current in the normal operation. In

addition, after being moved to the Brownout mode, there is another effect that the continuation time of the Battery Time mode can be determined dynamically by using a life time obtained based on the average value of direct current, in the case of power being supplied by the battery.

Having thus described several particular embodiments of the invention, various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this disclosure, and are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only, and not intended to be limiting. The invention is limited only as defined in the following claims and the equivalents thereto.

C L A I M S

1. A control system for uninterruptible power supply comprising:

- 5 (a) an uninterruptible power supply including a battery for supplying direct current (DC), for inputting alternating current (AC) from an alternating current power supply, converting the alternating current into direct current and outputting the direct current from one of the alternating current power supply and the battery;
- 10 (b) an electronic system operated by inputting the direct current output from the uninterruptible power supply; and
- (c) a controller for calculating a value of power consumption of the electronic system while the electronic system is operated by the direct current produced from the
15 alternating current power supply,

for calculating a life time of the battery based on residual charging capacity of the battery and the value of power consumption, when the electronic system starts operation by power from the battery, and

- 20 for outputting the life time to the electronic system.

2. The control system for uninterruptible power supply of claim 1, wherein the controller further includes:

- 25 AC power detecting means for detecting the power

consumption in the alternating current;

DC value calculating means for calculating a value of direct current based on the power consumption; and

life time predicting means for predicting the life time of the battery based on the value of direct current.

3. The control system for uninterruptible power supply of claim 2, wherein the controller further includes an efficiency table for storing conversion efficiency of converting from power consumption to direct current, and wherein the DC value calculating means calculates a value of direct current based on the power consumption using the efficiency table.

4. The control system for uninterruptible power supply of claim 3, wherein the efficiency table is defined to be corresponding to a voltage of the alternating current power supply.

5. A control system for uninterruptible power supply comprising:

(a) an uninterruptible power supply including a battery for supplying direct current, for inputting alternating current from an alternating current power supply, converting the alternating current into direct current and outputting the direct current from one of the alternating current power supply and the battery;

(b) an electronic system operated by inputting the

direct current output from the uninterruptible power supply; and

(c) a controller for calculating a life time of the battery based on residual charging capacity of the battery and a value of direct current from the battery, while the electronic system is operated by power from the battery, and for outputting the life time to the electronic system.

6. The control system for uninterruptible power supply of claim 5, wherein the controller further includes:

DC value detecting means for detecting the value of direct current from the battery; and

life time predicting means for predicting a life time of the battery based on the value of direct current.

7. The control system for uninterruptible power supply of claim 6, wherein the DC value detecting means detects an average value of direct current values at a specific period and regards the average value as a value of the direct current.

8. The control system for uninterruptible power supply of claim 2 or 6, wherein the controller further includes:

recognizing means for recognizing residual charging capacity of the battery; and

a battery life time table for storing a life time corresponding to the residual charging capacity of the

battery and the value of direct current,

wherein the life time predicting means included in the controller detects a life time using the battery life time table.

5 9. The control system for uninterruptible power supply of claim 6, wherein the controller further includes:

life time updating means for updating the life time according as time passes; and

10 prediction updating means for predicting a new life time by repeating detection of values of direct current detected by the DC value detecting means,

15 wherein the prediction updating means compares life times obtained by the life time updating means in order to define a shorter life time of the two as a new life time.

10. The control system for uninterruptible power supply of claim 5, wherein the controller divides an operating time of the electronic system operated by power from the battery into

20 an initial time in which it is regarded that a temporary abnormal condition is generated in the alternating current,

25 an intermediate time in which it is regarded that a continuous abnormal condition is generated in the alternating current, and

a last time in which stopping process of the electronic system is performed,

and wherein the intermediate time can be changed depending upon a length of the life time.

5 11. The control system for uninterruptible power supply of claim 10, wherein the controller maintains the initial time of a specific length.

10 12. The control system for uninterruptible power supply of claim 11, wherein the controller maintains the last time of a specific length.

13. The control system for uninterruptible power supply of claim 12, wherein the intermediate time is defined to be a time obtained by subtracting the last time and an unconsumed time in the initial time from the life time.

15 14. The control system for uninterruptible power supply of claim 13, wherein the controller stops being supplied power from the battery and outputs information on an normal condition to the electronic system when the alternating current is returned to the normal condition at the initial time and at the intermediate time.

20 15. The control system for uninterruptible power supply of claim 5 or 14, wherein the electronic system further includes receiving means for receiving information output from the controller and outputting means for outputting received information.

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16. The control system for uninterruptible power supply of claim 15, wherein the electronic system is a server connected to a client and the outputting means sends the received information to the client.

5 17. A control method for uninterruptible power supply, used for an electronic system operated by uninterruptible power supply, comprising the steps of:

(a) operating the electronic system by an alternating current power supply at an ordinary time;

10 (b) measuring power consumption during the electronic system operated by the alternating current power supply, in the operating step at an ordinary time;

(c) operating the electronic system by a battery at an extraordinary time;

15 (d) predicting a life time of the battery based on residual charging capacity of the battery and the power consumption measured by the power consumption measuring step, at a starting time of the operating step at an extraordinary time; and

20 (e) controlling operation of the electronic system based on the life time of the battery predicted by the predicting step.

18. A control method for uninterruptible power supply, used for an electronic system operated by uninterruptible power supply, comprising the steps of:

(a) operating the electronic system by an alternating current power supply at an ordinary time;

(b) operating the electronic system by a battery at an extraordinary time;

5 (c) periodically detecting an average value of residual charging capacity of the battery and direct current from the battery at a specific period while the electronic system is operated by the battery, in the operating step at an extraordinary time, and predicting and updating a
10 life time of the battery based on the average value of the residual charging capacity of the battery and the direct current from the battery; and

(d) controlling operation of the electronic system based on the life time of the battery predicted by the
15 predicting and updating step.

19. The control method for uninterruptible power supply of claim 17 or 18, wherein the controlling step includes the steps of:

regarding that a temporary abnormal condition is
20 generated in the alternating current power supply, as an initial step;

regarding that a continuous abnormal condition is generated in the alternating current power supply, as an intermediate step; and

25 stopping operation of the electronic system, as a

last step,

wherein a length of time of the intermediate step can be changed based on the predicted life time.

20. The control method for uninterruptible
5 power supply of claim 18, wherein the predicting and updating step sets a shorter time than a present life time as a new life time.

21. The control method for uninterruptible
power supply of claim 19, wherein the controlling step
10 changes a length of time of the intermediate step based on a new predicted life time.

22. A control system for uninterruptible power
supply constructed and arranged to operate substantially
as hereinbefore described with reference to and as
15 illustrated in Figures 1 to 18 of the accompanying drawings.

23. A control method for uninterruptible power
supply substantially as hereinbefore described with
reference to and as illustrated in Figures 1 to 18 of the
20 accompanying drawings.

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Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE, WPI	Date of completion of Search 14 SEPTEMBER 1995 Documents considered relevant following a search in respect of Claims :- ALL

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